Chapter 7
Global Climate Systems

Elemental Geosystems 5e

Robert W. Christopherson
Charles E. Thomsen

Earth's Climate System has many components and fluxes (energy and mass transfers between components).

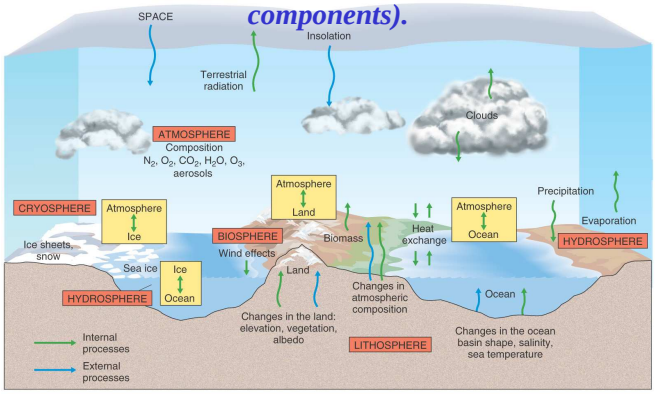
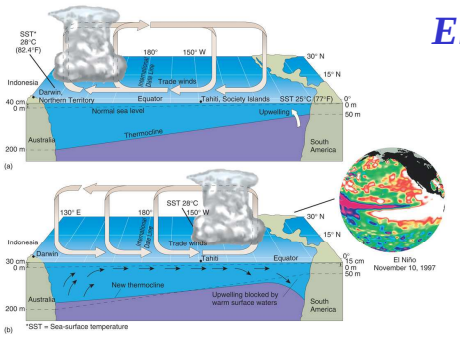
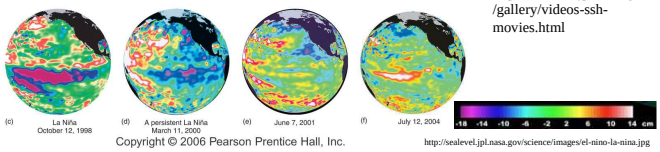


Figure 7.1

El Niño and La Niña



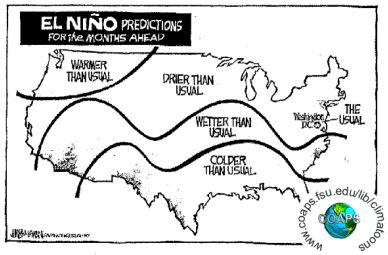


Colors are showing sea surface height, not temperature.
Movie: http://sealevel.jpl.nasa.gov/gallery/videos-ssh-movies.html

http://sealevel.jpl.nasa.gov/science/images/el-nino-la-nina.jpg

Present Day Climate Variability: El Niño

1. Notes on climate and climate variability
2. What is El Niño / ENSO?
3. ENSO mechanisms: atmosphere-ocean coupling
4. Past ENSO Events
5. Climatic impacts of ENSO
6. ENSO and climate prediction



1. Notes on climate and climate variability

CLIMATE is averaged weather. "Data" is the weather. "Climatology" is the climate.

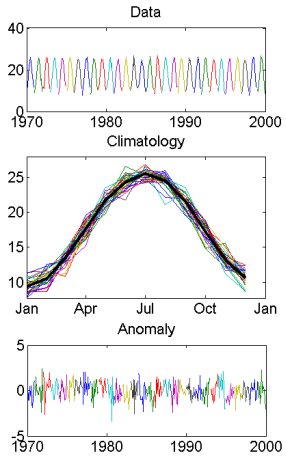
The World Meteorological Organization suggests a definition for climate to be an average over 30 years.

Climate variability is the fluctuations about the mean state. "Anomaly" shows the deviation from the normal climate. Also known as a "Departure." Mathematically:

Anomaly = Data - Climatology.

Climate change is a difference in the average conditions between two time spans**.**

Unlike the example at right, the real climate varies continuously - from season to season, year to year, decade to decade, century to century…



While El Nino is the largest single contributor to interannual variability in the globe, it is not the only one. Variability in any one location is usually determined by several sources.

Mark Twain, the climatologist:

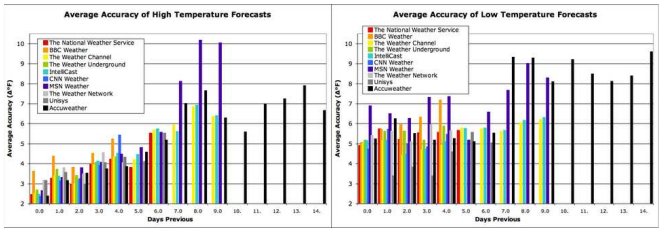
"The coldest winter I ever spent was summer in San Francisco."

"If you don't like the weather in New England, just wait a few minutes."

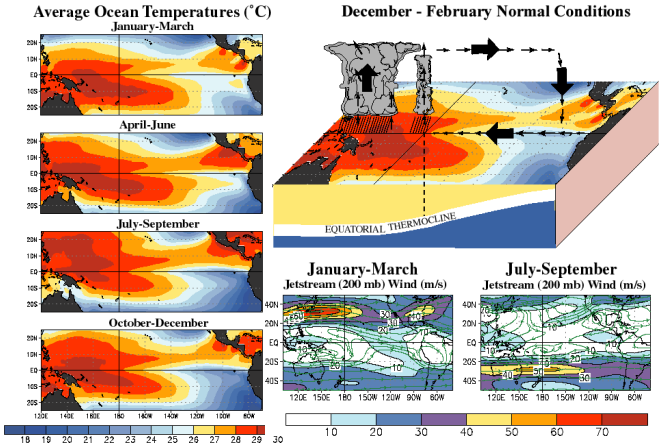
"Climate is what we expect, weather is what we get."

"Everybody talks about the weather but nobody does anything about it." -*Remembered Yesterdays* , Robert Johnson (although it appears his collaborator on *The Gilded Age* , Charles Dudley Warner, actually wrote the statement)

Weather forecasting is pretty good, for a few days.

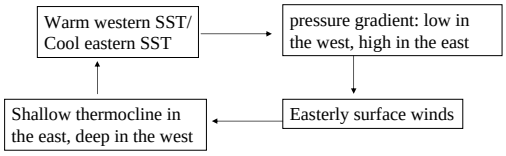


http://www.stat.columbia.edu/~cook/movabletype/archives/decision_theory/



All figures that do not have a credit in today's lecture are from:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml

Heart of ENSO physics: the Bjerknes feedback

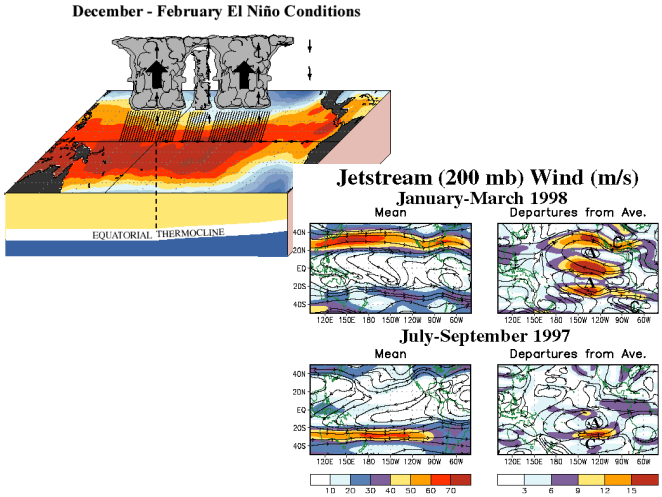


•In an El Niño, the thermocline initially deepens in the eastern equatorial Pacific

•East-west contrast in sea surface temperature reduces, and surface pressure reduces in the east, increases in the west.

•Anomalous winds blow from west to east because of the anomalous pressure gradient; atmospheric convection shifts from the western Pacific to the central Pacific

•Anomalous winds drive additional surface ocean waters eastward that deepen the thermocline in the eastern Pacific even further… Positive (Bjerknes) feedback



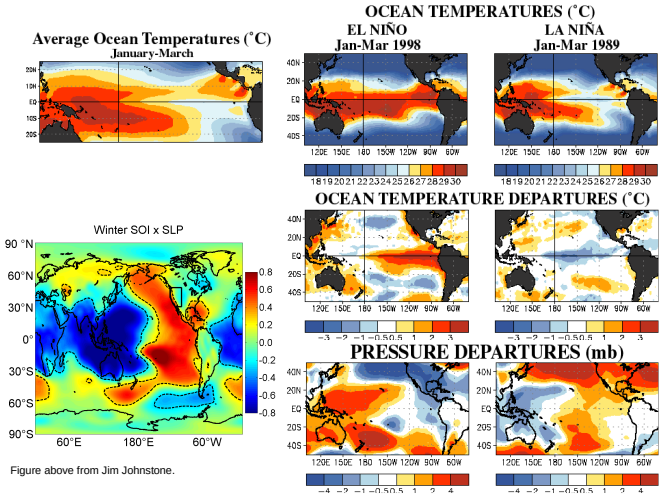
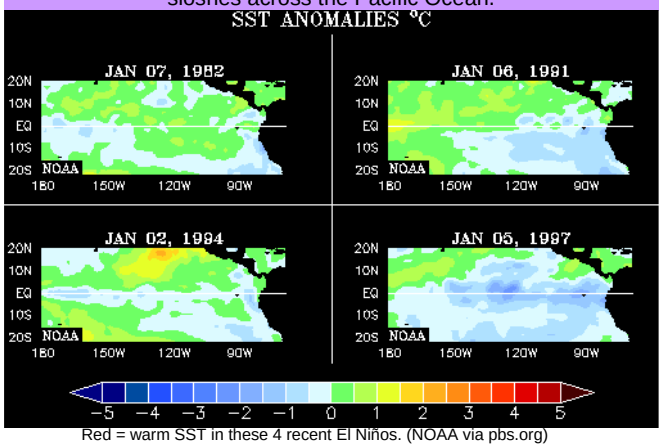
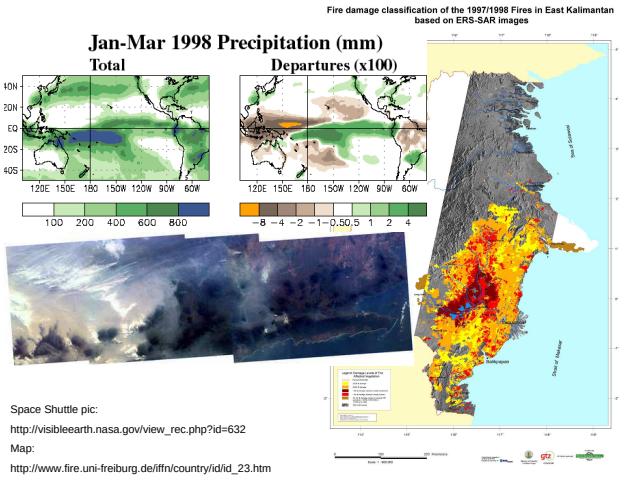


Figure above from Jim Johnstone.

In a narrow sense, El Nino is a giant puddle of heated water that sloshes across the Pacific Ocean.

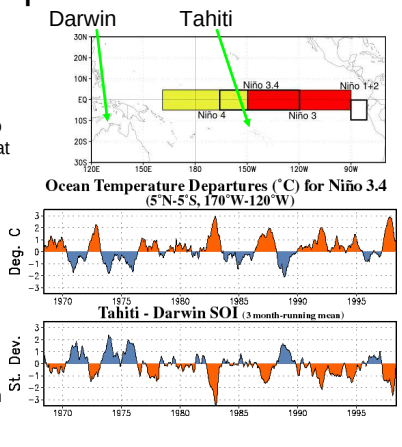


Red = warm SST in these 4 recent El Niños. (NOAA via pbs.org)



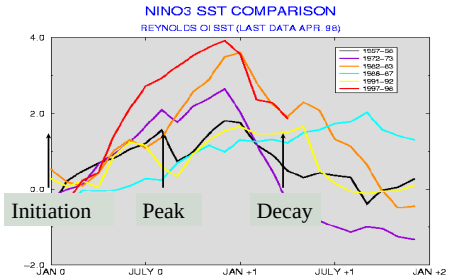
Space Shuttle pic:
http://visibleearth.nasa.gov/view_rec.php?id=632
Map:
http://www.fire.uni-freiburg.de/iffn/country/id/id_23.htm

Temporal pattern of ENSO



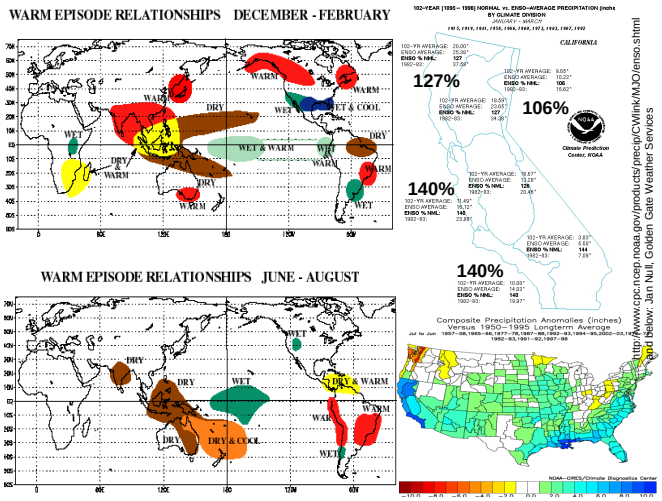
- Now that we've seen the spatial pattern of ENSO, we'll define two indices of ENSO so that we can look at the temporal pattern:
- 1) The Niño 3.4 SST index measures the SST in a region of the central equatorial Pacific
- 2) The Southern Oscillation Index is the pressure difference between Tahiti, French Polynesia and Darwin, Australia

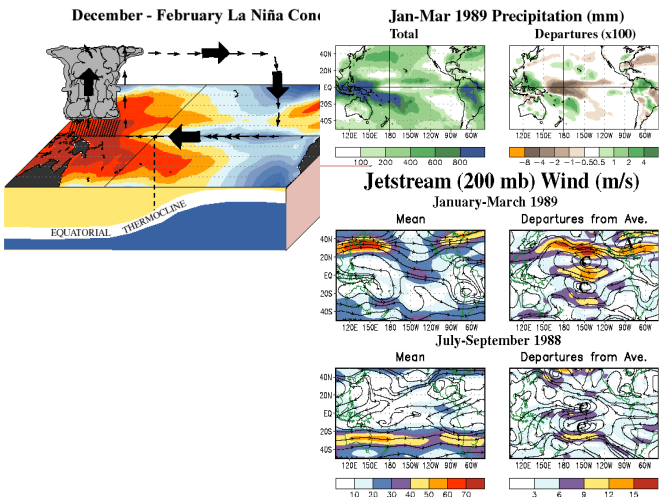
El Niño's Life Cycle

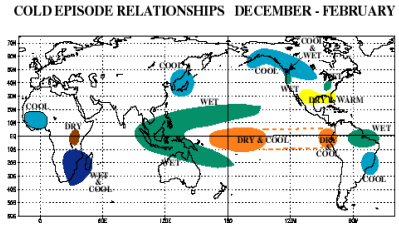


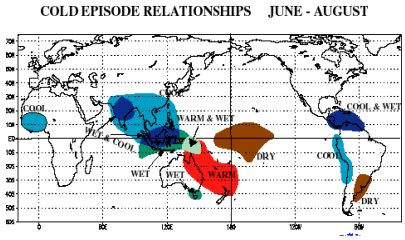
Source: International Research Institute for Climate Prediction

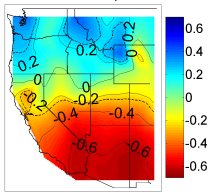
"The plumber says this has got something to do with that El Niño thing!"





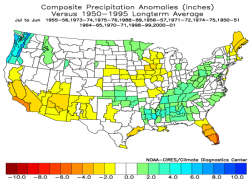


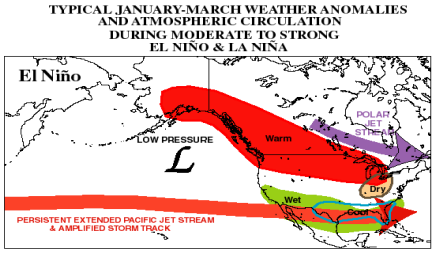


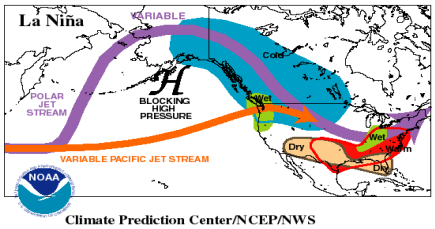


When the SOI is positive (La Niña), precip is large in the Pacific Northwest.

Figure above from Jim Johnstone
Below from Jan Null, Golden Gate Weather Services



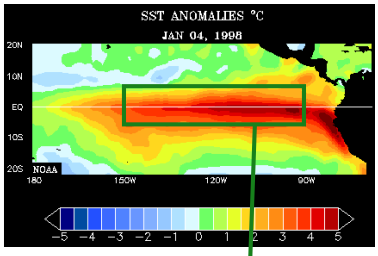


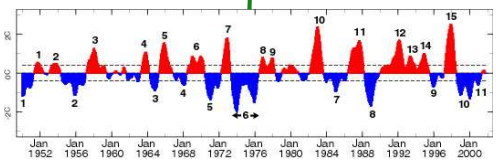


Climate Prediction Center/NCEP/NWS

ENSO Impact over North America

The influence on N.A. is related to the Pacific and polar jet streams. El Nino allows a persistent pacific jet stream to bring storms straight to California and lower N. America. But the anomalies are highly variable!



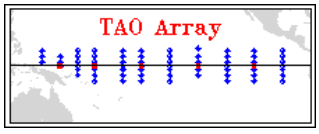


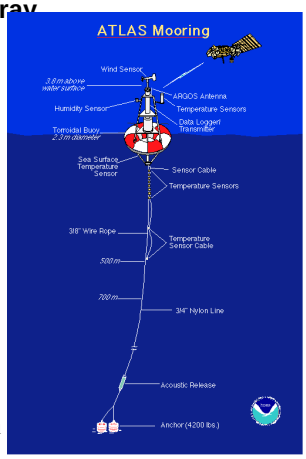
How do we know when El Niño occurs?

Pacific SST Anomalies Jan 1998 - El Niño

Red peaks: El Niño. Blue peaks: La Niña (opposite phase to El Niño)

Monitoring ENSO: the Tropical Atmosphere-Ocean (TAO) array



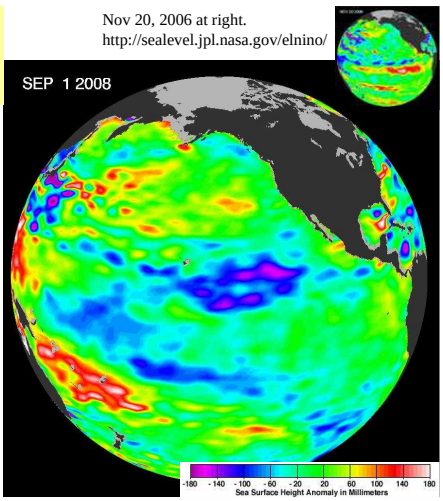


The TAO Array is a series of 69 carefully placed buoys in the tropical Pacific Ocean, started in 1985 and completed in December 1994. Each buoy has instruments that records air and sea temperature and they transmit their data to satellites daily. With all the buoys forming an array, there is a clearer picture of the changes that are a telltale sign of a coming El Niño.

http://www.oc.nps.navy.mil/webmodules/ENSO/TAO.html

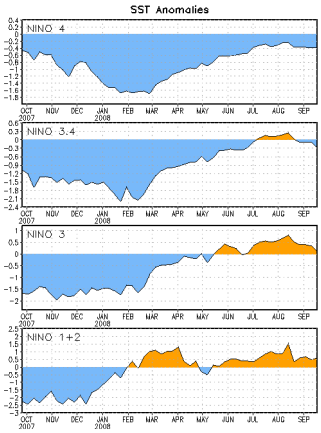
Fall 2008: A La Niña is decaying

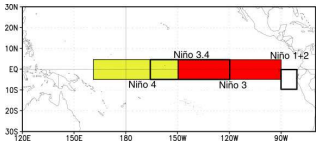
Nov 20, 2006 at right.
http://sealevel.jpl.nasa.gov/elnino/



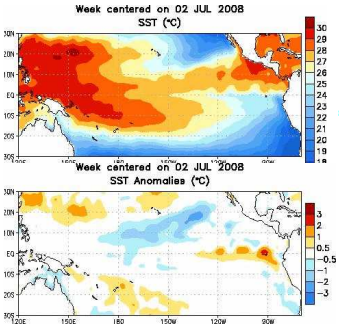
Niño Region SST Departures (°C) Recent Evolution

During the last 4-weeks, equatorial Pacific SSTs were below-average near the Date Line, and more than 0.5°C above-average between 120°W and 80°W.

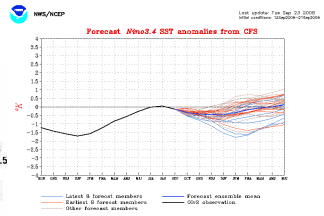




The present situation in the tropical Pacific: neutral and holding.



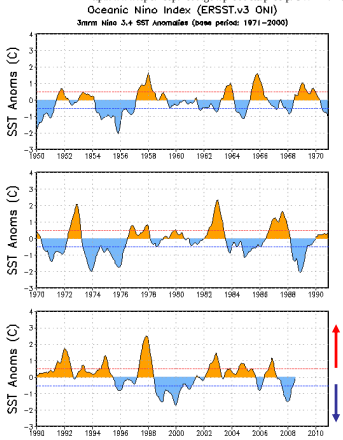
The CFS ensemble mean forecast (heavy blue line below) indicates neutral conditions for a while.



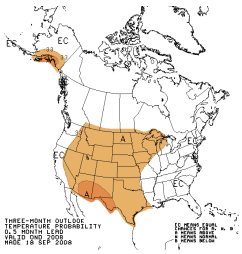
Oceanic Niño Index (°C): Evolution since 1950

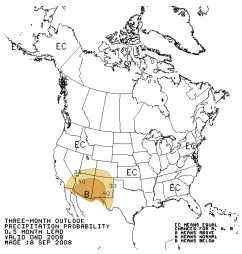
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#forecast

The most recent ONI value (June – August 2008) is -0.1°C.



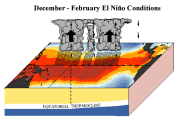
U. S. Seasonal Outlooks October – December 2008



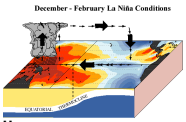


These seasonal outlooks combine long-term trends and soil moisture effects.

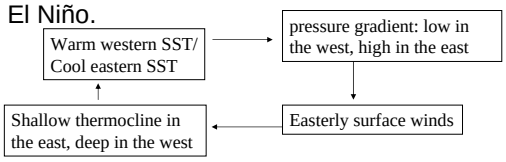
The biggest one of recent times The El Niño of 1998



Summary



- While El Nino is the largest single contributor to interannual variability in the globe, it is not the only one. Variability in any one location is usually determined by several sources.
- The Bjerknes Feedback is the mechanism that controls El Niño.



- Variability in the tropical Pacific ocean and atmosphere has global effects.